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14. ABSTRACT

An electronic mapping system, installed on a vehicle, can provide an accurate and visual depiction of the operating environment to the vehicle operator. This enhanced situational awareness (SA) is useful in critical decision-making and operational safety. The Naval Research Laboratory (NRL) has developed and tested a moving-map (MM) system based on commercial-off-the-shelf (COTS) hardware and government-off-the-shelf (GOTS) software for amphibious assault vehicles. The MM system consists of a computer, display and software depicting the position of the vehicle, obtained via the Global Position System (GPS), as an icon overlaid on a geo-registered map. This configuration can be run in either north-up or track-up mode. In north-up mode, the map is always displayed with north at the top of the display, and the icon moves as the position of the vehicle changes. In track-up mode, the map moves as the direction of travel changes with the forward direction at the top of the display. In this mode, the icon remains stationary over the moving map.

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electronic mapping system, operating environment, enhanced situational awareness

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HEADING SENSOR INTEGRATION WITH AN ELECTRONIC MOVING MAP SYSTEM

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Introduction

An electronic mapping system, installed on a vehicle, can provide an accurate and visual depiction of the operating environment to the vehicle operator. This enhanced situational awareness (SA) is useful in critical decision-making and operational safety. The Naval Research Laboratory (NRL) has developed and tested a moving-map (MM) system based on commercial-off-the-shelf (COTS) hardware and government-off-the-shelf (GOTS) software for amphibious assault vehicles. The MM system consists of a computer, display and software depicting the position of the vehicle, obtained via the Global Position System (GPS), as an icon overlaid on a geo-registered map. This configuration can be run in either north-up or track-up mode. In north-up mode, the map is always displayed with north at the top of the display, and the icon moves as the position of the vehicle changes. In track-up mode, the map moves as the direction of travel changes with the forward direction at the top of the display. In this mode, the icon remains stationary over the moving map.

Background

A common problem with many MM systems is that when the vehicle is stationary, the icon on the MM display will begin to randomly spin while in north-up mode, or the entire map will spin while in track-up mode due to a lack of independent heading information from GPS. The method that most GPS devices use to obtain heading is by using a formula, based on the current location and the last location of the device. When the two locations are the same, or very close, an error occurs, giving erratic heading information that can vary a great bit from one second to the next. This causes the MM system to believe that the heading is actually changing dramatically, when, in fact, the actual heading may not have changed at all. The resulting spinning icon or base map may cause operator disorientation and loss of SA.

The standard mathematical equation to derive true heading from two known points is:

$$\tan^{-1}\left(\frac{2\times\sin^{-1}\left(\dfrac{\sin(y-y')}{2}\right)}{\log\left(\tan\left(\dfrac{\pi}{4}+\dfrac{x'}{2}\right)\right)-\log\left(\tan\left(\dfrac{\pi}{4}+\dfrac{x}{2}\right)\right)}\right)\times\frac{180}{\pi}$$

$$x = \text{starting longitude} \qquad x' = \text{ending longitude}$$
$$y = \text{starting latitude} \qquad y' = \text{ending latitude}$$

As defined above, when the difference in longitude is zero, or when the points are so close that any difference is lost in round-off error, the equation reduces to:

$$\tan^{-1}\left(\frac{0}{0}\right)\times\frac{180}{\pi},$$

which is undefined since there is an attempted division by zero.

Approach

To correct this problem, NRL investigators integrated a COTS magnetic heading sensor into the MM system. For this purpose, a Furuno PG-1000 Magnetic Heading sensor was used. This device was chosen because of its availability and price. It should be noted here that COTS devices were used instead of standard military navigation devices because of their availability and overall cost-effectiveness. Their use in NRL tests and demonstrations does

not imply that they are more rugged or more accurate that GOTS devices. The task of NRL was to combine GOTS and COTS hardware and software in order to develop a cost-effective *demonstration* product. This particular hardware combination is not meant to be fielded, but only to demonstrate the effectiveness of such a system.

NRL Moving Map System

The original NRL Moving Map navigation system integrates COTS DGPS hardware with GOTS moving-map software. Table 1 lists system hardware and software components. The system includes a DGPS antenna and receiver capable of establishing exact position within 5-meter accuracy. A computer running the FalconView program, a component of the Portable Flight Planning System (PFPS) software suite, processes the DGPS data. The system can be loaded with a full range of military standard format charts from the National Imagery and Mapping Agency (NIMA), the National Oceanic and Atmospheric Administration (NOAA), and various conversion chart imports (such as geo-rectified GEOTIFF formats) of other non-military standard commercial products. Overlays (e.g., lane geometry) can be used to enhance situational awareness. Figures 1 and 2 show an example of a complete lane and a zoomed-in view that the driver might use, respectively.

Table 1. Components of NRL Moving Map System

Hardware Components	Software Components
Argonaut computer	Windows 2000 Operating System
Furuno DGPS receiver (GP-36)	FalconView (PFPS)
Furuno DGPS antenna	Heading Sensor Integration Software
1 Nauticomp display - 10.4"	

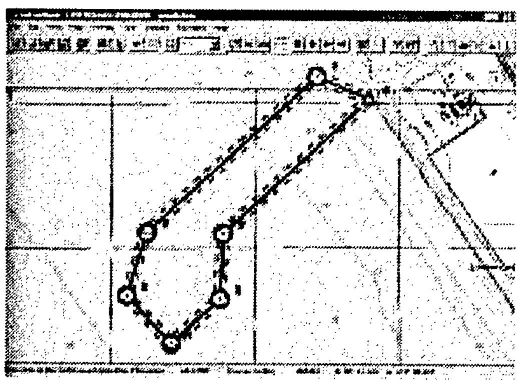


Figure 1 – Lane Geometry

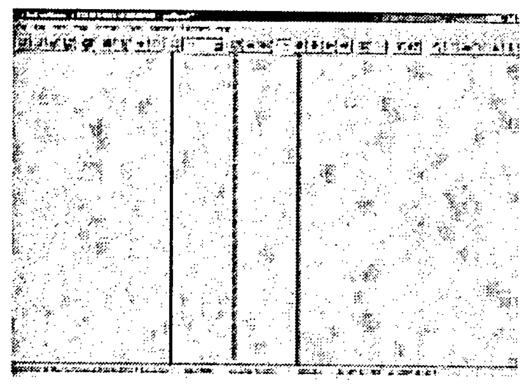


Figure 2 – Zoomed-In View

The following is a description of a sample setup in an Amphibious Assault Vehicle (AAV). The computer and DGPS receiver are located in the aft of the vehicle. The computer is contained in a water-resistant case (figure 3), and secured to the starboard side troop bench. This configuration is for a prototype installation, as the system location is not currently reasonable for actual military operations. The display is attached to the driver hatch, with an adjustable mounting. The DGPS antenna is located just forward of center on the outside of the vehicle. Figure 4 shows all of the major hardware components, to include the added magnetic heading sensor, which will be described in detail later. Figure 5 shows the driver's display, with the AAV driver hatch open. Figure 6 shows the display as it appears during actual operation.

Figure 3 – System Location

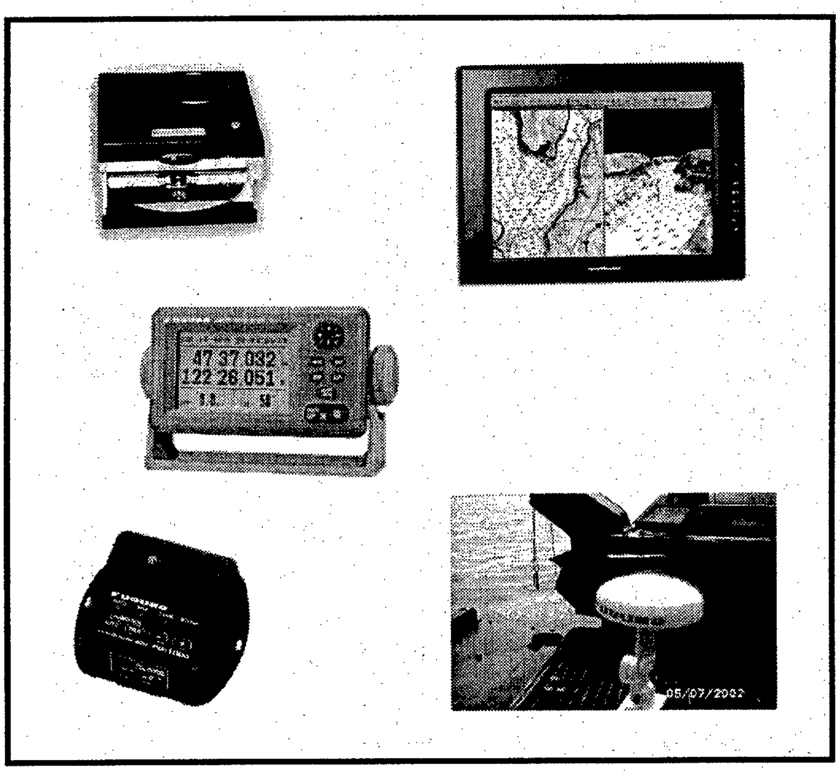


Figure 4 – Hardware Components

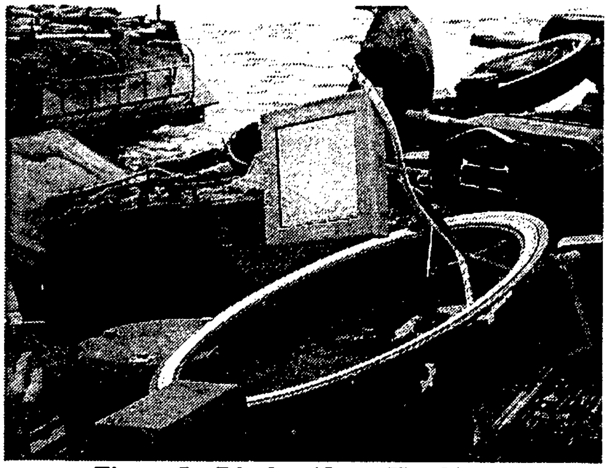


Figure 5 – Display (Open Hatch)

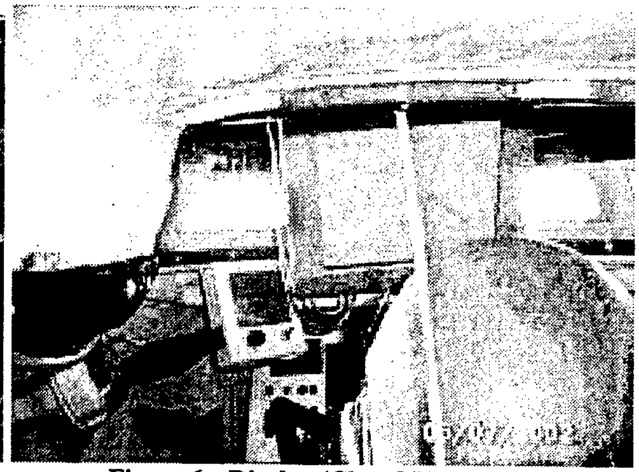
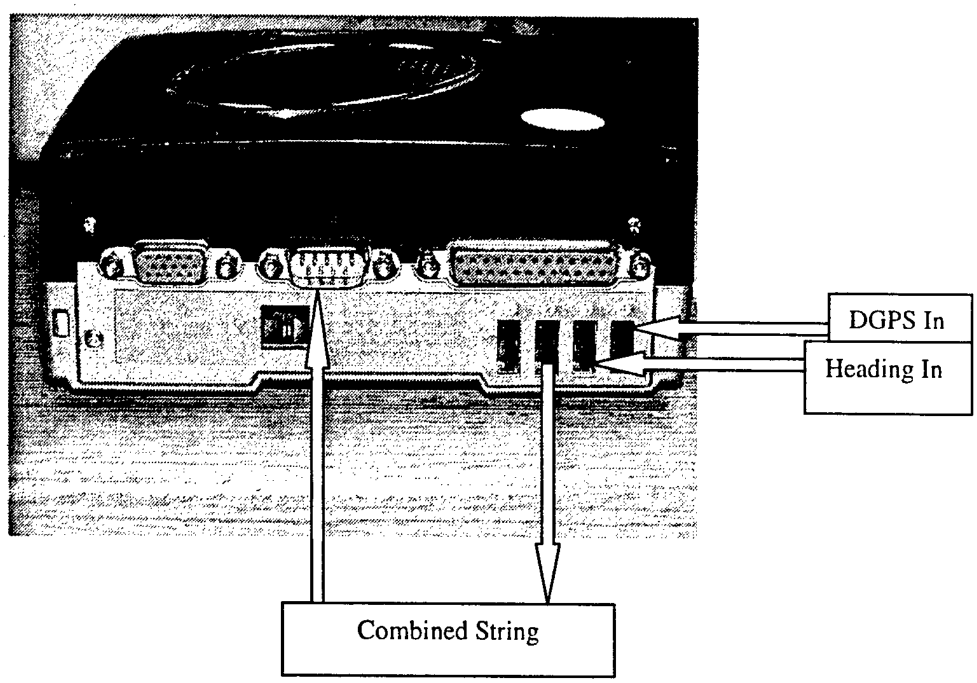


Figure 6 – Display (Closed Hatch)

Integrated Heading Sensor

To correct the spinning display/icon problem discussed earlier, NRL investigators decided upon a magnetic heading sensor manufactured by Furuno, the PG-1000. Because of the AAV's non-ferrous hull, a magnetic heading sensor was deemed appropriate and necessary. Because FalconView does not, at present, support more than a single input, NRL investigators had to write C code to integrate both the location information from the GPS and heading information into a single stream to send to the FalconView program. This integration software was run in the background, on the same computer as FalconView. Each device (DGPS and Heading Sensor) was connected to the computer by USB ports. The developed software took input from both USB ports, mated the input, and sent the integrated stream out a third USB port. The new input was then taken in at the serial port, from which the FalconView program was set to receive.



Code Samples

```
idComDev = CreateFile ("COM6", GENERIC_READ, 0, NULL, OPEN_EXISTING,
                FILE_ATTRIBUTE_NORMAL, NULL);
idComDev2 = CreateFile ("COM7", GENERIC_READ, 0, NULL, OPEN_EXISTING,
        FILE_ATTRIBUTE_NORMAL, NULL);
```

```
idComDev3 = CreateFile ("COM1", GENERIC_WRITE, 0, NULL, OPEN_EXISTING,
        FILE_ATTRIBUTE_NORMAL, NULL);
.
.
.
ReadFile(idComDev2, &d, 1, &bytes_read, NULL);
ReadFile(idComDev, &d, 1, &bytes_read, NULL);
.
.       Process and combine data
.
WriteFile (idComDev3, nmea, size, &bytes_written, NULL);
```

Conclusions

NRL successfully integrated a magnetic heading sensor into an existing Moving Map system. This resulted in better situational awareness for the vehicle driver. This also led to better overall accuracy during test runs as compared to those made without the heading sensor. The added processing time was minimal, and not noticeable to the human eye, which was a goal for investigators at NRL.

Acknowledgements

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